UPPER CRETACEOUS FORAMINIFERA FROM THE BALLYDEENLEA CHALK, COUNTY KERRY, IRELAND

by F. T. BARR

Abstract. Twenty-three species of Upper Cretaceous foraminifera have been recovered from the newly discovered (Walsh 1960) Ballydeenlea Chalk of County Kerry, Ireland. These are the first Upper Cretaceous foraminifera reported from the Republic of Ireland and the westernmost Upper Cretaceous fauna found in Europe. This faunal assemblage shows that the Ballydeenlea Chalk can be correlated with part of the Upper Chalk (Senonian) of England and Northern Ireland. The presence of *Bolivinoides decorata* (Jones) in this fauna indicates further that the Ballydeenlea Chalk is, at least in part, Upper Campanian in age and equivalent to the *Belemnitella mucronata* zone of the British Isles and Western Europe.

In 1960, while systematically mapping the Upper Palaeozoic rocks of the Killarney District, County Kerry, Dr. P. T. Walsh discovered a small pocket of hard white chalk within the typical dark Palaeozoic shale and limestone of the area. This chalk was exposed in a disused quarry in Ballydeenlea townland, six miles north of Killarney, and had been quarried for perhaps over a century until 1930. The exposure may have been known to geologists in the past, but until Walsh's (1960) initial investigation, there is no record in the literature that any geological significance had ever been attributed to this exposure. Walsh collected material from this quarry and soon both megafossils and microfossils suggestive of an Upper Cretaceous age were recognized. The megafossils consisted chiefly of fragments of *Inoceramus sp.* and fragments of unidentifiable echinoids. Foraminifera were observed in thin section and although specific identifications could not be made, generic determinations suggested that the Ballydeenlea Chalk was Upper Cretaceous in age. This was the first recognition of Cretaceous rocks in the Republic of Ireland.

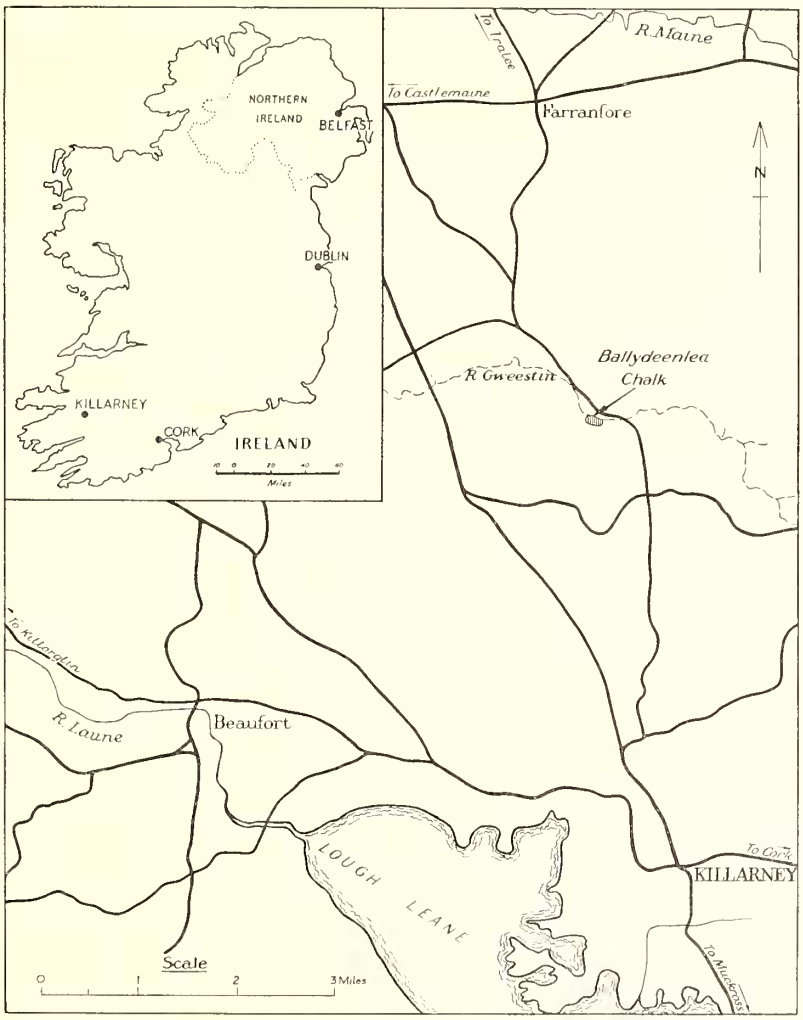
The Ballydeenlea Chalk is a pocket-like mass surrounded by Palaeozoic rocks. The minimum dimensions of this deposit are approximately 130 ft. by 300 ft. and the thickness is about 100 ft. The Ballydeenlea Chalk shows no bedding and consists chiefly of a hard white limestone. Flint nodules typical of the Upper Cretaceous Chalk of England and Northern Ireland are common. Angular fragments of brecciated dark shale are also abundant throughout most of the deposit. These fragments vary in size from a few millimetres to pieces several feet across. This shale has so far been found to be unfossiliferous.

Walsh (1966) gives a detailed description of the Ballydeenlea Chalk and several other deposits in the Killarney district which may possibly be related. He concludes that the Ballydeenlea Chalk represents a karst collapse deposit. Prior to Upper Cretaceous times, a large cavern formed in the Carboniferous limestone. During the late Cretaceous, an arm of the sea transgressed over this area, probably from the west, depositing a marine sequence of white chalk over the Killarney district. Soon afterwards, the roof of the limestone cavern collapsed and the cavern was filled by the overlying Upper Cretaceous Chalk along with fragments of dark Palaeozoic shales from the roof. The Ballydeenlea

[Palaeontology, Vol. 9, Part 3, 1966, pp. 492–510, pls. 77–79.]

Chalk was thus protected from later erosion, whereas the great bulk of Upper Cretaceous sediments deposited over this part of Ireland was removed by Cenozoic erosion.

The preservation of this small deposit of Upper Cretaceous Chalk is indeed fortunate.



TEXT-FIG. 1. Map showing location of the Ballydeenlea Chalk in Co. Kerry, south-western Ireland.

Its presence has considerably changed some of the fundamental ideas about the palaeogeography of Ireland during the Upper Cretaceous. The purposes of this present study are: (1) to date the Ballydeenlea Chalk more exactly, which should add to the precision of palaeogeographic reconstruction; (2) to show that earlier suggestions (Walsh 1960, p. 113) that the Ballydeenlea Chalk was equivalent to the Middle Chalk (Turonian) are incorrect; and (3) to describe and document the first Upper Cretaceous foraminifera found in the Republic of Ireland, and which also constitute the westernmost Upper Cretaceous fauna in Europe.

Acknowledgements. I thank Dr. P. T. Walsh for supplying the material from the Ballydeenlea Chalk on which this study is based, and discussing various problems related to this deposit; Miss Elizabeth R. Hill, Mr. Wilf Austin, and Mr. John Smith for help with the manuscript; and my wife, Melza, for preparing the illustrations of foraminifera.

Deposition of types. All specimens illustrated in this paper and additional material from the Ballydeenlea Chalk are deposited in the British Museum (Natural History).

PALAEONTOLOGY AND AGE OF THE BALLYDEENLEA CHALK

The Ballydeenlea Chalk is predominantly a hard white limestone which was found difficult to disaggregate. First attempts to obtain foraminifera in a free form from this well-indurated rock were unsuccessful. Consequently, foraminifera were first observed only in thin section. Thin sections of the Ballydeenlea Chalk characteristically exhibit fairly common foraminifera in addition to abundant small fossil fragments. On the basis of these foraminifera, Dr. F. T. Banner and Dr. W. H. Blow (British Petroleum Co.) expressed the opinion that this Irish chalk was equivalent to the Middle Chalk (Turonian) (Walsh 1960, p. 113).

I subsequently experimented with various techniques to disaggregate this tough limestone and obtain specimens of foraminifera in a free state, and met with partial success using the following method:

1. The limestone was crushed down to fine pebble size.
2. This material was then heated in a dilute solution of hydrogen peroxide for several hours.
3. The residue was then washed through a 200-mesh sieve.
4. The remaining fraction was then placed in an ultrasonic vibrator for 30 to 45 minutes.

This is rough treatment for delicate foraminifera and no doubt many specimens were destroyed or damaged. Nevertheless, by using large amounts of material and repeating this process many times, a large, although generally poorly preserved, fauna was finally obtained. In addition to the foraminifera recovered, molluscan and echinoid fragments were common, siliceous sponge spicules were abundant, fish teeth were rare, and a single ostracod was found. The following foraminifera are recorded from the Ballydeenlea Chalk:

Ammodiscus cretacea (Reuss)
Glomospira cf. *gordialis* (Jones and Parker)
Textularia sp.
Trochammminoides sp.
Haplophragmoides sp.
Ataxophragmium variablis (d'Orbigny)
Arenobulimina cf. *sphaerica* Marie
Lagena acuticosta Reuss
Nodosaria limbata (?) d'Orbigny
Dentalina cf. *communis* (d'Orbigny)
Lenticulina sp.
Praebulimina obtusa (d'Orbigny)
Bolivinitella eleyi (Cushman)
Bolivinoides decorata (Jones)

Heterohelix globulosa (Reuss)
Gyroidinoides umbilicata (d'Orbigny)
Eponides cf. *concinna* Brotzen
Globigerinelloides aspera (Ehrenberg)
Rugoglobigerina sp.
Gavelinella lorniana (d'Orbigny)
Gavelinella thalmanni (Brotzen)
Gavelinella sp.
Cibicides beaumontiana (d'Orbigny)

It is not certain how well this list of foraminifera represents the complete fauna. By analogy with faunas usually obtained from the Upper Cretaceous Chalk of southern England, one would suspect that this list represents only a fraction of the complete fauna. The methods used to disaggregate the limestone probably introduced a considerable bias in the fauna obtained.

Nevertheless, the foraminifera recovered from the Ballydeenlea Chalk can be used to date this deposit precisely. It must be pointed out that it is possible that the Ballydeenlea Chalk may consist of a mixture of sediments of several different ages. However, all the species recovered can occur together within a faunal assemblage of a single age. Many of the species range in the British Isles and Western Europe throughout most of the Senonian (see text-fig. 2); other species have a stratigraphic range of Middle Senonian to Maestrichtian. The bulk of the fauna, therefore, indicates that the Ballydeenlea Chalk is a time equivalent to part of the Upper Chalk (Senonian) of England, not the Middle Chalk (Turonian) as was previously suggested. Furthermore, about twelve specimens of *Bolivinoides decorata* (Jones) were recovered. This species is restricted to the *Belemnitella mucronata* Zone (Upper Campanian) of England, Northern Ireland, and Western Europe in general (Barr 1966), and its presence therefore indicates that the Ballydeenlea Chalk, at least in part, is Upper Campanian in age and a time equivalent to the *B. mucronata* Zone of England and Northern Ireland.

SYSTEMATIC PALAEONTOLOGY

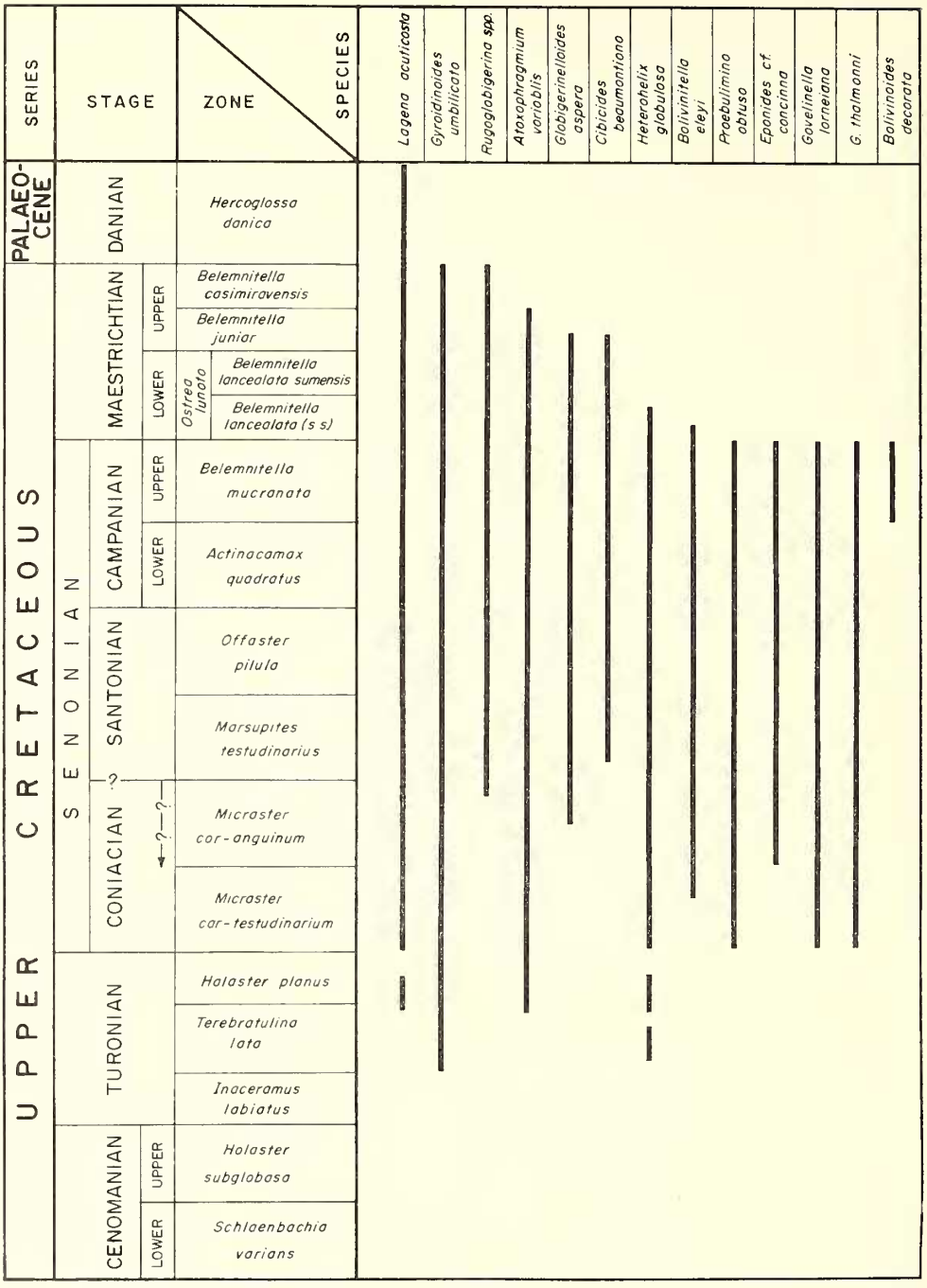
Family AMMODISCIDAE Reuss 1862
Subfamily AMMODISCINAE Reuss 1862
Genus AMMODISCUS Reuss 1862

Ammodiscus cretacea Reuss

Plate 77, fig. 2

Operculina cretacea Reuss 1845, p. 35, pl. 13, figs. 64, 65.
Cornuspira cretacea Reuss; Reuss 1860, p. 177, pl. 1, fig. 1.
Ammodiscus gaulticus Berthelin; Brotzen 1936, p. 31, pl. 1, figs. 3 *a*, *b*.
Ammodiscus cretacea (Reuss); Marie 1941, p. 18, pl. 1, figs. 5–6.
Ammodiscus cretaceus (Reuss); Cushman 1946, pp. 17, 18, pl. 1, fig. 35 (see synonymy).
Ammodiscus cretaceus (Reuss); Hagn 1953, pp. 4, 5, fig. 3.
Involutina cretacea (Reuss); Belford 1960, pp. 22, 23, pl. 6, fig. 1.

Occurrence. Rare distorted specimens of *A. cretacea* were recovered from the Ballydeenlea Chalk. This species, although usually rare, has a wide geographic distribution and ranges throughout much of the Upper Cretaceous.



TEXT-FIG. 2. Chart showing the stratigraphic ranges in the British Isles and Western Europe of some of the Foraminifera recovered from the Ballydeenlea Chalk. Based chiefly on Barr (1961, 1962, 1966).

Genus GLOMOSPIRA Rzehak 1885
Glomospira cf. *gordialis* (Jones and Parker)

Trochammina squamata var. *gordialis* Jones and Parker 1860, p. 304.
Trochammina squamata var. *gordialis* Jones and Parker; Parker and Jones 1865, p. 408, pl. 15, fig. 32.
Glomospira gordialis Jones and Parker; Cushman 1946, pp. 18, 19, pl. 1, figs. 38–40 (see synonymy).

Occurrence. A single specimen was recovered from the Ballydeenlea Chalk; it appears to be identical to specimens illustrated by Cushman (1946, p. 18, pl. 1, figs. 38–40). Cushman (op. cit., p. 19) recorded *G. gordialis* from the Austin Chalk, Taylor Marl, and Velasco Shale of the Gulf Coastal Area of the U.S.A. and Mexico.

Family ATAXOPHRAGMIIDAE Schwager 1877
Subfamily ATAXOPHRAGMIINAE Schwager 1877
Genus ATAXOPHRAGMIUM Reuss

Ataxophragmium variablis (d'Orbigny)

Bulimina variablis d'Orbigny 1840, p. 40, pl. 4, figs. 9–11.
Ataxogyroidina variablis (d'Orbigny); Barnard and Banner 1953, pp. 205, 206, pl. 9, figs. 6 *a*, *b*; text-figs. 7 *a–l* (see synonymy).

Remarks. There is considerable variation in the general test shape, configuration of apertural face, and in shape of aperture. Barnard and Banner (1953, text-figs. 7 *a–l*) illustrated much of this variation.

Occurrence. Rare specimens of *A. variablis* were recovered from the Ballydeenlea Chalk. This species is abundant in the Senonian Chalk of southern England, the Paris Basin, and other parts of Western Europe.

Subfamily GLOBOTEXTULARIINAE Cushman 1927*a*
Genus ARENOBULIMINA Cushman 1927*a*

Arenobulimina cf. *sphaerica* Marie

Arenobulimina sphaerica Marie 1941, p. 49, pl. 4, figs. 36 *a–e*.

Remarks. Three specimens of a small *Arenobulimina* recovered from the Ballydeenlea Chalk closely resemble *A. sphaerica* Marie in most respects. The poor preservation of these specimens, however, does not allow a positive identification.

A. sphaerica was originally described from the *B. mucronata* Zone of the Paris Basin.

Family LITUOLIDAE de Blainville 1825
Subfamily HAPLOPHRAGMOIDINAE Maync 1952
Genus TROCHAMMINOIDES Cushman 1910

Trochamminoides sp.

Plate 77, figs. 1 *a*, *b*

Description. Test planispiral, loosely coiled, evolute, biumbilicate, often distorted; periphery in side view circular; 6–9 indistinct chambers in final whorl, uniformly and rapidly

increasing in size; sutures indistinct, weakly depressed, slightly curved, radial; wall finely arenaceous.

Remarks. This species is similar to *Trochamminoides velascoensis* Cushman in some respects, but can easily be distinguished by its larger size, greater and rapidly increased thickness, and less compressed test.

Occurrence. This species is rare in the Ballydeenlea Chalk. Specimens of an unnamed species of *Trochamminoides* have been observed in the Campanian of the Sacramento Valley, California, and appear to be conspecific with this Irish form.

Family NODOSARIIDAE Ehrenberg 1838
Subfamily NODOSARIINAE Ehrenberg 1838
Genus NODOSARIA Lamarck 1812

Nodosaria limbata (?) d'Orbigny

Nodosaria limbata d'Orbigny 1840, p. 12, pl. 1, fig. 1.
Nodosaria limbata d'Orbigny; Franke 1928, p. 42, pl. 3, figs. 27, 28.
Nodosaria limbata d'Orbigny; Cushman and Jarvis 1932, p. 32, pl. 10, fig. 5.
Nodosaria concinna Reuss; Cushman and Jarvis 1932 (*non* Reuss), pp. 31, 32, pl. 10, fig. 4.
Nodosaria limbata d'Orbigny; Cushman 1946, p. 74, pl. 27, figs. 1, 2 (see synonymy).
Dentalina concinna (Reuss); Hagn 1953 (*non* Reuss), pp. 43, 44, pl. 4, fig. 18.
Nodosaria limbata d'Orbigny; Said and Kenawy 1956, p. 133, pl. 2, fig. 32.
Dentalina catenula catenula Reuss; Pożaryska 1957 (*non* Reuss), pp. 76, 77, pl. 9, fig. 8.
Nodosaria limbata d'Orbigny; Belford 1960, pp. 38, 39, pl. 11, figs. 7–9.

Occurrence. Rare broken specimens of *Nodosaria* were recovered from the Ballydeenlea Chalk. These fragments appear to be identical to the specimens of *N. limbata* in the d'Orbigny Collection in Paris; however, because of the incompleteness of the only specimens recovered, there is still some uncertainty as to this identification. I have also found specimens of *N. limbata* in the *B. mucronata* Zone (Upper Campanian) of southern England and in the *B. lanceolata* Zone (Lower Maestrichtian) at Sidestrand, Norfolk. D'Orbigny (1840, p. 12) originally described this species from the *B. mucronata* Zone at Meudon in the Paris Basin.

Genus LAGENA Walker and Jacob 1798

Lagena acuticosta Reuss

Plate 77, figs. 7, 8

Lagena acuticosta Reuss 1862, p. 305, pl. 1, fig. 4.
Lagena acuticosta Reuss; Egger 1899, p. 106, pl. 5, fig. 12.

EXPLANATION OF PLATE 77

All specimens are from the Ballydeenlea Chalk, ×125.

Fig. 1. *Trochamminoides sp.* 1*a*, side view; 1*b*, end view; P45707.
Fig. 2. *Ammodiscus cretacea* Reuss, side view; P45710.
Fig. 3. *Praebulimina obtusa* (d'Orbigny); P45702.
Figs. 4, 5. *Bolivinoides decorata* (Jones). 4, side view, final chamber broken; P45693. 5*a*, side view; 5*b*, end view; P45692.
Fig. 6. *Bolivinitella eleyi* (Cushman). 6*a*, side view; 6*b*, edge view; P45698.
Figs. 7, 8. *Lagena acuticosta* Reuss. 7, P45699. 8, P45700.


1a

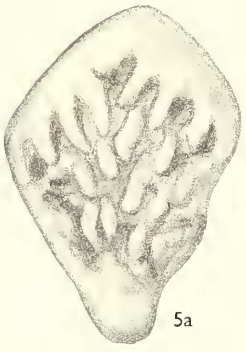

1b


2


5b


3


4


5a


6a


6b


7


8

BARR, Foraminifera from Ballydeenlea Chalk

Lagena isabella (d'Orbigny); Franke 1925 (*non* d'Orbigny), p. 60, pl. 4, fig. 40.
Lagena isabella (d'Orbigny); Franke 1928, p. 87, pl. 8, fig. 1.
Lagena acuticosta Reuss; Cushman 1931*a*, p. 308, pl. 35, fig. 12.
Lagena acuticosta Reuss; Cushman 1932, p. 337, pl. 50, fig. 13.
Lagena isabella (d'Orbigny); Brotzen 1936 (*non* d'Orbigny), pp. 111, 112, pl. 7, fig. 5; text-fig. 37.
Lagena cayeuxi Marie 1941, pp. 74, 75, pl. 9, figs. 82, 83.
Lagena amphora Reuss; Schijfsma 1946, p. 54, pl. 2, fig. 17.
Lagena acuticosta Reuss; Cushman 1946, p. 94, pl. 39, figs. 14, 15.
Lagena acuticosta Reuss; Visser 1951, pp. 234, 235, pl. 2, fig. 1.
Lagena acuticosta Reuss; Frizzell 1954, p. 102, pl. 14, figs. 1, 2.
Lagena cf. *cayeuxi* Marie; McGugan 1957, p. 339, pl. 31, fig. 22.
Lagena acuticosta Reuss; Martin 1964, p. 61, pl. 5, figs. 2*a*, *b*.

Occurrence. Six specimens of *L. acuticosta* Reuss were found in the Ballydeenlea Chalk. This species has a long stratigraphical range and great geographical distribution; it ranges from the *M. cor-testudinarium* Zone (Coniacian) to the top of the *B. mucronata* Zone (Upper Campanian) on the Isle of Wight. I have also found this species in the Lower Maestrichtian of Norfolk, the Lower Maestrichtian of southern Limberg, and the Upper Maestrichtian of Stevns Klint, Denmark. Cushman (1946, p. 94) reported that *L. acuticosta* had a wide distribution in the Gulf Coastal area of the U.S.A., occurring in strata of Austin to Navarro age.

Family TURRILINIDAE Cushman 1927*a*
Subfamily TURRILININAE Cushman 1927*a*
Genus PRAEBULIMINA Hofker 1953

Praebulimina obtusa (d'Orbigny)

Plate 77, fig. 3

Bulimina obtusa d'Orbigny 1840, p. 39, pl. 4, figs. 5, 6.
Bulimina laevis Beissel 1891 (part), p. 66, pl. 12, figs. 42, 43 (*non* figs. 39–41).
Bulimina elegans d'Orbigny; Chapman 1892 (*non* d'Orbigny), p. 516 (list), pl. 15, fig. 9.
Bulimina elegans d'Orbigny; Heron-Allen and Earland 1910, p. 409, pl. 6, fig. 11.
Bulimina ovulum Reuss; Franke 1925, p. 25, pl. 2, fig. 17.
Bulimina ovulum Reuss; Franke 1928, p. 157, pl. 14, fig. 14.
Buliminella carseyae Plummer; Dain 1934 (*non* Plummer), p. 37, pl. 4, fig. 38.
Buliminella laevis (Beissel); Cushman and Parker 1936, p. 6, pl. 2, figs. 3*a–c*.
Buliminella obtusa (d'Orbigny); Brotzen 1936, p. 131, pl. 8, figs. 2*a*, *b*.
Buliminella obtusa (d'Orbigny) forma typica; Marie 1941, p. 198, pl. 30, figs. 291*a–f*.
Buliminella obtusa (d'Orbigny) *inflata* Marie 1941, p. 199, pl. 30, figs. 192*a–e*.
Buliminella obtusa (d'Orbigny) *laevis* (Beissel); Marie 1941, p. 199, pl. 30, figs. 293*a–e*; pl. 31, figs. 294*a–e*.
Buliminella obtusa (d'Orbigny); Schijfsma 1946, p. 80, pl. 4, fig. 9.

Description. Test free, tapering, approximately $1\frac{1}{2}$ times longer than wide, consisting of 4 to 5 whorls each containing 3 to 4 weakly inflated chambers rapidly and uniformly increasing in size; spiral sutures depressed; chamber sutures curved, flush or weakly depressed; aperture slit-like or loop-shaped opening along inner margin of final chamber, often also extending up into chamber face bordered by thin narrow lip; tooth plate simple, narrow, attached to inner side of aperture and extending into penultimate aperture; wall calcareous, smooth, finely perforate.

Remarks. P. obtusa occurs commonly throughout the Senonian chalk of southern England. In the middle and upper parts of the *B. mucronata* Zone, it becomes

progressively larger, more inflated and more ovate, and eventually evolves into a distinctively larger form which is indicative of the latest Campanian and Maestrichtian in Western Europe.

Occurrence. D'Orbigny (1840, pp. 39, 40) originally described this species from the Upper Cretaceous localities at Meudon and Saint-Germain in the Paris Basin. Marie (1941, pp. 197–9) reported three varieties of this species from the *B. mucronata* Zone of the Paris Basin, and Schijfsma (1946, p. 80) records *P. obtusa* from the Campanian of southern Limberg, Netherlands. *P. obtusa* is common in the Ballydeenlea Chalk.

Family BOLIVINITIDAE Cushman 1927*a*
Genus BOLIVINOIDES Cushman 1927*a*

Bolivinoides decorata (Jones)

Plate 77, figs. 4, 5

Bolivinoides decorata (Jones); Barr 1966, pp. 220–43, pl. 34, figs. 2–6, 12; pl. 35, figs. 6–9; pl. 36, figs. 1–5. Full synonymy.

Remarks. B. decorata (Jones), a species common to the *B. mucronata* Zone of southern England and Northern Ireland, has recently been described in detail (Barr 1966). A lectotype was established from a series of syntypic specimens in the Joseph Wright Collection, which is located in the Queen's University, Belfast (op. cit. pp. 231–4, pl. 36, figs. 1 *a*, *b*). *B. decorata* was shown to have exceptional value as an index fossil of the Upper Campanian.

The direct ancestor of *B. decorata* appears to be *B. hiltermanni* Barr. The latter gave rise to *B. decorata* at the beginning of the Upper Campanian (base of the *B. mucronata* Zone). The *A. quadratus* Zone–*B. mucronata* Zone (Lower Campanian–Upper Campanian) contact in southern England can be located with some accuracy at the stratigraphic position where *B. hiltermanni* is replaced by *B. decorata* (s.s.). *B. decorata* differs from its ancestor, *B. hiltermanni*, by having a larger, more flaring test with a small length/breadth ratio (usually 1·5 to 1·8 compared with 1·9 to 2·3 which is most usual for *B. hiltermanni*). The surface sculpture is more distinct on *B. decorata* and there are more lobes on the final chambers, most often 4 or 5, whereas *B. hiltermanni* usually possesses 3 on its latest chambers.

Bolivinoides miliaris Hiltermann and Koch is similar to *B. decorata* (Jones) in many respects and appears to have been derived from *B. decorata* during the late *B. mucronata* Zone. *B. decorata* is distinguished from *B. miliaris* by having a slightly greater length/breadth ratio and a more elongate, less rhomboidal lateral outline. The maximum breadth of *B. decorata* is closer to the apertural end, whereas the maximum breadth of *B. miliaris* is nearer the mid-point of the test. The surface lobes of *B. miliaris* are less regular than those of *B. decorata* and there is more of a tendency for them to fuse with the lobes on the earlier chambers.

Edgell (1954, pp. 71, 72) described a new subspecies which he named *B. decorata* (Jones) *australis*. This subspecies is a form transitional between *B. decorata* (Jones) and *B. gigantea* Hiltermann and Koch. Barr (1966) re-examined type specimens of *B. decorata australis* and concluded that this form was closer morphologically to *B. gigantea* and was quite distinct from *B. decorata* (s.s.). *B. australis* appears to have evolved from

B. decorata (s.s.) at the beginning of the Maestrichtian. It can be distinguished from *B. decorata* by: (1) having a smaller length/breadth ratio; (2) having more surface lobes on the final chambers (5 to 7 on the final chamber compared with 4 or 5 for *B. decorata* s.s.); (3) possibly being more commonly ornamented near its initial end; and (4) sometimes having a more rhomboidal outline.

Occurrence. Approximately twelve specimens of *Bolivinoides decorata* were recovered from the Ballydeenlea Chalk. However, most of these specimens were broken or damaged to varying degrees.

B. decorata occurs in abundance throughout the *B. mucronata* Zone in southern England and appears to be restricted to this zone (Barr 1966). The type locality for this species is at Keady Hill, County Derry, Northern Ireland, which is probably in the upper part of the *B. mucronata* Zone.

B. decorata also occurs in the Ballycastle Pellet Chalk of Northern Ireland (McGugan 1957, p. 339, pl. 32, figs. 10–15; Barr 1966). However, it appears that this formation was derived by Tertiary erosion of an Upper Cretaceous land surface (Charlesworth 1963, p. 369) and that the contained foraminifera were also derived from the nearby Upper Cretaceous Chalk.

Genus BOLIVINITELLA Marie 1941

In 1854, Ehrenberg proposed the generic name *Loxostomum*, but unfortunately neither gave a description of this new genus nor designated a type species. However, he listed seven new Upper Cretaceous species which he considered to belong to this genus: *Loxostomum aculeatum*, *L. anglicum*, *L. curvatum*, *L. rostratum*, *L. subrostratum*, *L. tumens*, and *L. vorax*. None of these species was described and the only illustrations were of specimens mounted in balsam and viewed by transmitted light. Consequently, there have been few attempts to use Ehrenberg's species of *Loxostomum* and most of them must be considered *nomina dubia*.

Cushman (1927*b*) subsequently fixed the type species of the genus *Loxostomum* as *L. subrostratum* Ehrenberg. In various editions of Cushman's classification (e.g. 1955, p. 269, pl. 27, figs. 30–32), he described *Loxostomum* as follows: 'Test in early stages similar to *Bolivina*, adult tending to become uniserial; aperture terminal.—Cretaceous to Recent.' Cushman included *Bolivina plaita* Carsey in the genus *Loxostomum*. Subsequent authors have considered this species typical of the genus and have based their concept of *Loxostomum* on this and similar forms.

Marie (1941, pp. 189, 190) erected the genus *Bolivinitella* and designated the well-known species *Bolivinita eleyi* Cushman as the type species. Marie (op. cit., p. 191, pl. 29, figs. 282*a–c*) illustrated a typical specimen of *B. eleyi* from the *B. mucronata* Zone (Upper Campanian) at Montereau, and listed the occurrence of this species from numerous other localities in the Paris Basin in the *B. mucronata* Zone, including Meudon (one of the two localities from which Ehrenberg (1854) originally recovered his specimens of *Loxostomum subrostratum*).

Following suggestions made by Hofker (1952), Loeblich and Tappan (1962, pp. 110, 111) placed *Bolivinitella* Marie and *Loxostomum* Ehrenberg in synonymy. They suppressed *Bolivinitella* as a junior synonym of *Loxostomum* and erected a new genus, *Coryphostoma*, in which they placed many species previously referred to *Loxostomum* (e.g. *Bolivina plaita* Carsey). Loeblich and Tappan pointed out that Marie (1941)

recorded *Bolivinitella* forma typica from Meudon, a locality from which Ehrenberg originally described *Loxostomum subrostratum*. They concluded: 'the specimens illustrated as *B. eleyi* by Marie (1941, pl. 29, figs. 282 *a–c*) are typical of *L. subrostratum* and the two "species" are not only congeneric, but almost certainly conspecific.'

At best the suppression of *Bolivinitella* as a junior synonym of *Loxostomum* is premature. Ehrenberg never described *L. subrostratum* and the only illustration is a drawing of a specimen viewed by transmitted light. Consequently, *L. subrostratum* is not well enough known to be recognized with any assurance. Furthermore, I have collected material from the Upper Cretaceous Chalk at Meudon with M. Pierre Marie which indeed contains numerous specimens of *Bolivinitella eleyi*; however, there are a number of other biserial forms present (e.g. *Bolivina plaita*) which might conceivably belong to the true *Loxostomum subrostratum*. Therefore, at least until Ehrenberg's original specimens can be re-examined, it would seem best to continue the usage of *Bolivinitella* as a valid genus.

Bolivinitella eleyi (Cushman)

Plate 77, figs. 6*a*, *b*

Textularia obsoleta Reuss; Eley 1859 (*non* Reuss), p. 202, pl. 8, fig. 11*c*.
Bolivina obsoleta Eley; Jones 1872, p. 124 (list).
Bolivinita eleyi Cushman 1927*a*, p. 91, pl. 12, figs. 11 *a*, *b*.
Bolivinita eleyi Cushman; Cushman 1931*b*, p. 39, pl. 5, figs. 8 *a*, *b*.
Bolivinita eleyi Cushman; Cushman 1932, p. 338, pl. 51, figs. 7 *a*, *b*.
Bolivina quadrilatera (Schwager); Macfadyen 1932, pp. 492, 493, pl. 35, figs. 21 *a*, *b*.
Bolivinita quadrilatera (Schwager); Dain 1934, pp. 34, 35, pl. 3, fig. 35.
Bolivinita eleyi Cushman; Brotzen 1936, p. 122, pl. 9, figs. 5 *a*, *b*, text-fig. 41.
Bolivinitella eleyi (Cushman); Marie 1941, p. 190, pl. 29, figs. 282 *a*, *b*.
Bolivinita eleyi Cushman; Cushman 1946, p. 114, pl. 48, figs. 18–20.
Bolivinitella eleyi Cushman; Schijfsma 1946, pp. 72, 73, pl. 6, fig. 10.
Bolivinita eleyi Cushman; Hagn 1953, p. 76, pl. 6, fig. 24.
Bolivinitella eleyi (Cushman); Frizzell 1954, p. 112, pl. 16, figs. 23 *a*, *b*.
Bolivinitella eleyi (Cushman); McGugan 1957, p. 340.
Bolivinitella eleyi (Cushman); Montanaro Gallitelli 1957, p. 150, pl. 34, figs. 14–17.
Bolivinitella eleyi (Cushman); Belford 1960, p. 62, pl. 15, figs. 20, 21.
Bolivinitella eleyi (Cushman); Akimets 1961, pp. 192, 193, pl. 19, figs. 9 *a*, *b*.
Bolivinita eleyi Cushman; Kaptarenko-Chernousova *et al.* 1963, p. 113, pl. 19, figs. 7 *a*, *b*.
Bolivinitella eleyi (Cushman); Graham and Church 1963, p. 51, pl. 5, figs. 25 *a*, *b*.

Description. Test elongate, compressed, sometimes twisted, rectangular in cross-section, with up to 16 chambers arranged biserially, almost becoming uniserial in final stage; sides nearly parallel or gradually tapering; lateral sides flat or slightly concave, chambers reniform, arched, overlapping; sutures distinct, limbate, flush or very slightly raised, fusing at edges, forming a thin longitudinal keel along each edge; wall calcareous, very finely perforate, surface smooth; aperture a thin terminal slit; approximate length 0·56 mm.; breadth 0·20 mm.; thickness 0·09 mm.

Occurrence. *B. eleyi* is fairly common in the Ballydeenlea Chalk. It is common in southern England, where it ranges from the base of the *M. cor-anguinum* Zone to the top of the *B. mucronata* Zone. *B. eleyi* also occurs in lowermost Maestrichtian strata

of Western Europe and North Africa. The holotype is from the upper Brownstone Marl of Arkansas.

Family HETEROHELICIDAE Cushman 1927*a*
Subfamily HETEROHELICINAE Cushman 1927*a*
Genus HETEROHELIX Ehrenberg 1843

Heterohelix globulosa (Ehrenberg)

Plate 78, figs. 5, 6

Textularia globulosa Ehrenburg 1840, p. 135, pl. 4, figs. 2, 4, 5, 7, 8.
Textilaria globulosa Ehrenburg; Ehrenburg 1854, pl. 21, fig. 87.
Textularia globulosa Ehrenberg; Eley 1859, pp. 194, 202, pl. 2, fig. 9; pl. 9, fig. 9.
Textilaria globifera Reuss 1860, p. 232, pl. 13, figs. 7, 8.
Textularia decurrens Chapman 1892, p. 515, pl. 15, fig. 6.
Gümbelina globulosa (Ehrenberg); Egger 1899, p. 32, pl. 14, fig. 43.
Textularia globifera Reuss; Franke 1925, p. 11, pl. 1, fig. 13.
Textularia globulosa Ehrenberg; Franke 1928, p. 134, pl. 12, fig. 11.
Pseudotextularia globulosa (Ehrenberg); Macfadyen 1932, pl. 35, fig. 22.
Gümbelina globulosa (Ehrenberg); Morrow 1934, p. 194, pl. 29, figs. 18*a*, b.
Gümbelina globifera (Reuss); Loetterle 1937, p. 34, pl. 5, fig. 3.
Gümbelina globulosa (Ehrenberg); Cushman 1946, pp. 105, 106, pl. 45, figs. 9–15 (see synonymy).
Gümbelina globulosa (Ehrenberg); Williams-Mitchell 1948, p. 99, pl. 9, fig. 2.
Gümbelina globulosa (Ehrenberg); Loeblich 1951, p. 108, pl. 12, figs. 4, 5.
Gümbelina globulosa (Ehrenberg); Hagn 1953, p. 73, pl. 6, figs. 16, 17.
Gümbelina globulosa (Ehrenberg); Frizzell 1954, p. 109, pl. 15, figs. 24–27.
Heterohelix globulosa (Ehrenberg); Montanaro Gallitelli 1957, pl. 31, figs. 12–15.
Gümbelina globulosa (Ehrenberg); Belford 1960, p. 59, pl. 15, figs. 10, 11.
Heterohelix globulosa (Ehrenberg); Said and Kerdany 1961, p. 331, pl. 2, fig. 1.
Heterohelix globulosa (Ehrenberg); Graham and Church 1963, pp. 61, 62, pl. 7, figs. 11*a*, *b*.
Heterohelix globulosa (Ehrenberg); Barr and Cordey 1964, pp. 306, 307, pl. 49, fig. 4.
Heterohelix globulosa (Ehrenberg); Takayanagi 1965, pp. 195, 196, pl. 20, figs. 1*a*, *b* (see synonymy).

Remarks. H. globulosa is distinguished by its tapering test, lobulate periphery, and smooth globular chambers. Specimens of *H. globulosa* are fairly common in the Ballydeenlea Chalk, but most are somewhat smaller than typical specimens of this species.

Occurrence. H. globulosa occurs in abundance throughout the Senonian of southern England. Williams-Mitchell (1948, pl. 10) recorded the range of this species in the Chalk of England as *I. labiatus* Zone (Lower Turonian) to the *B. mucronata* Zone. *Textularia decurrens* Chapman (= *H. globulosa*) was originally described from the phosphatic chalk at Taplow, Buckinghamshire, which is referred to the *M. testudinarius* Zone (Santonian) (Barr and Cordey 1964, pp. 306, 307).

Family PLANOMALINIDAE Bolli, Loeblich, and Tappan 1957
Genus GLOBIGERINELLOIDES Cushman and ten Dam 1948

Globigerinelloides aspera (Ehrenberg)

Plate 78, figs. 4*a*, *b*

Rotalia aspera Ehrenberg 1854, p. 24, pl. 27, figs. 57, 58; pl. 28, fig. 42; pl. 31, fig. 44.
Phanerostomum asperum Ehrenberg 1854, p. 23, pl. 30, figs. 26*a–b*.

Rotalia aspera Ehrenberg; Beissel 1891, p. 73, pl. 14, figs. 1–6.
Globigerina aequilateralis (*non* Brady); Chapman 1892, p. 517, pl. 15, fig. 14.
Globigerina aequilateralis (*non* Brady); Heron-Allen and Earland 1910, p. 424, pl. 8, figs. 11, 12.
Globigerinella aspera (Ehrenberg); Brotzen 1936, p. 170, pl. 13, fig. 2.
Globigerinella aspera (Ehrenberg); Schijfsma 1946, pp. 94–96, pl. 6, fig. 8.
Globigerinella aspera (Ehrenberg); Bandy 1951, p. 508, pl. 75, fig. 3.
Globigerinella aspera (Ehrenberg); Belford 1960, p. 91, pl. 25, figs. 4–6.
Planomalina aspera (Ehrenberg); Barr 1962, pp. 561, 563, pl. 69, figs. 4*a*, *b*.
Planomalina (*Globigerinelloides*) *aspera aspera* (Ehrenberg); van Hinte 1963, p. 97, pl. 12, figs. 2*a*, 3.
'*Globigerinella*' *aspera* (Ehrenberg); Graham and Church 1963, pp. 64, 65, pl. 7, figs. 17*a–c*.
Globigerinelloides aspera (Ehrenberg); Barr and Cordey 1964, p. 309.
Globigerinelloides asper (Ehrenberg); Takayanagi 1965, pp. 201, 202, pl. 20, figs. 9*a–c*.

Occurrence. Approximately twelve specimens of *G. aspera* were recovered from the Ballydeenlea Chalk, and additional specimens were observed in thin section. *G. aspera* appears to be the most common planktonic species found in this chalk; it has a wide geographic distribution, occurring in most areas of the world where Senonian planktonic faunas are found. Barr (1962) recorded *G. aspera* in abundance from the Isle of Wight, ranging from the lower *M. cor-anguinum* Zone to the upper *B. mucronata* Zone. It is also found in the lower and middle Maestrichtian of continental Europe. Barr and Berggren (1965) recorded specimens of *G. aspera* from the Palaeocene Thanet Formation of eastern Kent. These specimens, along with other Upper Cretaceous species found in the Thanet Formation, were undoubtedly derived from the nearby Campanian Chalk.

Family GLOBOTRUNCANIDAE Brotzen 1942
Genus RUGOGLOBIGERINA Brönnimann 1952

Rugoglobigerina sp.

Plate 78, figs. 2, 3

Remarks. Several small specimens of *Rugoglobigerina* were recovered from the Ballydeenlea Chalk. The chambers of these forms were coarsely hispid and arranged in a very low trochospiral. These specimens could not be specifically identified, but are generally similar to several species that occur in the Campanian chalk of western Europe.

EXPLANATION OF PLATE 78

All specimens are from the Ballydeenlea Chalk, ×175.

Fig. 1. *Gavelinella thalmanni* (Brotzen). 1*a*, dorsal view, juvenile specimen; 1*b*, end view; 1*c*, ventral view; P45703.

Figs. 2, 3. *Rugoglobigerina sp.* 2*a*, dorsal view; 2*b*, end view; 2*c*, ventral view; P45709. 3*a*, dorsal view; 3*b*, ventral view, showing final chamber broken; P45708.

Fig. 4. *Globigerinelloides aspera* (Ehrenberg). 4*a*, lateral view; 4*b*, end view; P45701.

Figs. 5, 6. *Heterohelix globulosa* (Ehrenberg). 5, lateral view, initial end missing; P45704. 6, lateral view of exceptionally small specimen; P45705.


1a


1b

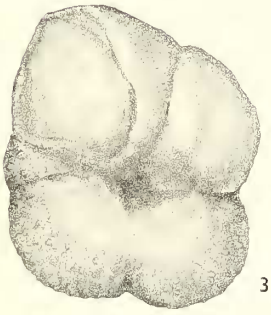

1c


2a


2b


2c


3a


3b


4a


5


6


4b

BARR, Foraminifera from Ballydeenlea Chalk

Family EPONIDIDAE Hofker 1951
Genus EPONIDES de Montfort 1808

Eponides cf. *concinna* Brotzen

Plate 79, figs. 2*a–c*

Epionides concinna Brotzen 1936, p. 167, pl. 12, figs. 4*a–c*.

Description. Test trochoid, consisting of about 3 whorls, biconvex; dorsal side weakly convex, nearly evolute, early whorls somewhat obscured by thin smooth mass of hyaline calcite; ventral side convex, involute, umbilicate; periphery in side view circular, weakly lobulate, with slight keel; chambers weakly inflated, ventrally overlapping, 9 to 12 in final whorl, uniformly and gradually increasing in size; ventral sutures distinct, depressed, dorsal sutures indistinct on early whorls, distinct on final whorl, limbate, flush, slightly curved, oblique; aperture narrow slit at base of final chamber, extending from umbilicus to periphery, bordered by thin, narrow lip; umbilicus small, shallow, often partially filled by low umbilical plug; wall calcareous, finely perforate, surface smooth.

Remarks. The morphology of the umbilical area of specimens referred to *Eponides* cf. *concinna* varies considerably. The umbilicus varies from a shallow simple form through ones containing a slightly raised plug to umbilici almost completely filled by a well-developed umbilical plug. The original illustration of the holotype of *E. concinna* shows a small shallow umbilicus with no umbilical plug. Although the specimens in the present study are similar in most respects to the type specimen from Sweden, there is still some uncertainty as to their relationship. On the other hand, the Ballydeenlea specimens appear to be identical to specimens from the Upper Cretaceous Chalk of southern England which range from the base of the *M. cor-anguinum* Zone to the upper part of the *B. mucronata* Zone.

Family OSANGULARIIDAE Loeblich and Tappan 1964
Genus GYROIDINOIDES Brotzen 1942

Gyroidinoides umbilicata (d'Orbigny)

Plate 79, figs. 3*a–c*

Rotalina umbilicata d'Orbigny 1840, pl. 3, figs. 4–6.
Rotalina nitida Reuss; Beissel 1891, p. 71, pl. 14, figs. 14–16.
Rotalia soldanii umbilicata (d'Orbigny); Franke 1927, p. 692.
Gyroidina umbilicata (d'Orbigny); Cushman 1931*b*, p. 43, pl. 6, fig. 3.
Gyroidina umbilicata (d'Orbigny); Macfadyen 1932, p. 489 (list), pl. 35, figs. 27*a*, *b*.
Gyroidina nitida (Reuss); Brotzen 1936, pp. 157–9, pl. 11, figs. 3*a–c*; text-fig. 58.
Gyroidina umbilicata (d'Orbigny); Marie 1941, pp. 219, 220, pl. 34, figs. 318*a–c*.
Gyroidina nitida (Reuss); Schijfsma 1946, pp. 85, 86, pl. 5, figs. 1*a–c*.
Gyroidina nitida (Reuss); Williams-Mitchell 1948, p. 97, pl. 8, figs. 6*a–c*.
Gyroidina umbilicata (d'Orbigny); McGugan 1957, p. 342, pl. 33, fig. 4.

Description. Test trochoid, planoconvex, composed of 3 to $3\frac{1}{2}$ whorls; dorsal side flat, evolute, ventral side strongly convex, involute, umbilicate, periphery in side view broadly rounded; chambers weakly inflated, 7 to 8 chambers in final whorl, uniformly and gradually increasing in size; ventral sutures straight, radial, flush; early dorsal sutures on final whorl depressed, slightly curved, nearly radial, dorsal spiral suture in early whorls

flush, indistinct, in final whorl distinct, depressed; aperture narrow slit at base of final chamber, extending from ventral umbilicus on to dorsal side, bordered by thin narrow lip; umbilicus narrow, shallow, sometimes partially covered by apertural lip; wall calcareous, finely perforate, surface smooth.

Occurrence. G. umbilicata is common in the Ballydeenlea Chalk. This species has a long stratigraphic range in Western Europe. In southern England, *G. umbilicata* ranges from the Upper Turonian to the top of the Campanian. It is also abundant in the Lower Maestrichtian chalk at Sidestrand, Norfolk.

Family ANOMALINIDAE Cushman 1927*a*
Subfamily ANOMALININAE Cushman 1927*a*
Genus GAVELINELLA Brotzen 1942

Gavelinella lorneiana (d'Orbigny)

Plate 79, figs. 1*a–c*

Rosalina lorneiana d'Orbigny 1840, p. 36, pl. 3, figs. 20–22.
Anomalina (*Rosalina*) *lorneiana* (d'Orbigny); Egger 1909, p. 45, pl. 4, figs. 10–12.
Anomalina clementiana (d'Orbigny); Cushman 1931*b*, p. 46, pl. 6, figs. 10*a–c*.
Discorbis lorneiana (d'Orbigny); Marie 1941, pp. 214–16, pl. 33, figs. 314*a–c*.
Anomalina clementiana (d'Orbigny); Cushman 1946 (part), p. 155, pl. 63, figs. 13*a–c* (*non* figs. 12 *a–c*).
Gavelinella lorneiana (d'Orbigny); Loeblich and Tappan 1964, p. 759, figs. 621 (6*a–c*).

Occurrence. Rare specimens of *G. lorneiana* were recovered from the Ballydeenlea Chalk. I have found this species in abundance at Culver Cliff, Isle of Wight, where it ranges from the *M. cor-testudinarium* Zone (Coniacian) to the lower part of the *B. mucronata* Zone. D'Orbigny (1840, p. 37) originally described this species from the Upper Campanian localities of St. Germain and Meudon in the Paris Basin, where he recorded it in abundance, and from Sens (Lower Campanian) and England, where he found only rare specimens. Marie (1941, p. 215) also reported *G. lorneiana* from various localities in the *B. mucronata* Zone (Upper Campanian) of the Paris Basin.

Gavelinella thalmanni (Brotzen)

Plate 78, figs. 1*a–c*

Cibicides thalmanni Brotzen 1936, pp. 190, 191, pl. 14, figs. 7*a–c*.

Description. Test flatly trochoid, nearly planispiral, consisting of about $2\frac{1}{2}$ tightly coiled whorls; dorsal side weakly convex, semi-evolute, umbilicate; ventral side flat, involute,

EXPLANATION OF PLATE 79

All specimens are from the Ballydeenlea Chalk.

Fig. 1. *Gavelinella lorneiana* (d'Orbigny), ×95. 1*a*, dorsal view; 1*b*, end view; 1*c*, ventral view, umbilicus obscured by matrix; P45694.
Fig. 2. *Eponides* cf. *concinna* Brotzen, ×125. 2*a*, dorsal view; 2*b*, end view; 2*c*, ventral view; P45697.
Fig. 3. *Gyroidinoides umbilicata* (d'Orbigny), ×125. 3*a*, dorsal view; 3*b*, end view; 3*c*, ventral view; P45695.
Fig. 4. *Cibicides beaumontiana* (d'Orbigny), ×125. 4*a*, ventral view; 4*b*, end view; 4*c*, dorsal view, final chamber broken, umbilical area obscured by matrix; P45696